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Physicochemical changes of sweet cherry fruits related to application of gibberellic acid

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Abstract

The influence of gibberellic acid on the physical and chemical properties of sweet cherry fruits during ripening (development of fruit colour) and at fruit maturity (firmness of fruits, cracking index, water uptake, soluble solids content, total acidity, fruit dimensions) of three sweet cherry cvs. 'Van', 'Sunburst' and 'Elisa' grown in a climate with frequent rainfall during fruit maturation were studied. Fruits of cv. 'Elisa' were prematurely picked because of cracking. A significant main effect of GA_3 treatment and significant main effect of cultivars were established in fruit colour development. The means of firmness and soluble solids content were systematically higher for the cherries of 'Van' and 'Sunburst' treated with GA_3 but they were not significant at $\alpha = 0.05$. The fruit cracking was significantly smaller for GA_3-treated fruits of the cv. 'Sunburst' after 4 h in water. Gibberellic-treated fruits of both cultivars were larger in fruit weight than untreated fruits; the differences were significant at $\alpha = 0.10$. Fruit dimensions: height, width and thickness of both cultivars were significantly affected by GA_3 treatment. The response of sweet cherry fruits to GA_3 spraying depended on the properties of the cultivar.

Keywords: Sweet cherry; Gibberellic acid; Colour; Firmness; Water uptake; Fruit cracking; Fruit dimensions; Soluble solids; Acidity; Repeated measures experimental design; Linear mixed models

1. Introduction

Sweet cherries are very attractive fruits and one of the few non-surplus fruit crops in Europe (Esti, Cinquanta, Sinesio, Moneta, & Mateo, 2002); production is therefore not limited only to the areas with ideal environmental conditions. In many of the European sweet cherry production areas, rain occurring in the period of cherry ripening causes crop losses. Fruit cracking, fruit softening and rapid decay after harvest are major problems which cause crop losses in sweet cherry production. This is the reason for frequent premature picking of sweet cherry fruits of lower fruit quality. Early-harvested cherries show insufficient size, low content of soluble solids and moderate colour. It is reported that treatment with the gibberellic acid (GA_3) influences sweet cherry fruit quality and can reduce negative effects of rain and premature picking (Facteau, Chestnut, Rowe, & Payne, 1992; Looney, 1996).

In fruit growing, gibberellic acid is frequently applied as it affects the shape of fruits (causes elongation of fruits), decreases fruit russeting and influences the development of parthenocarpic fruits. Further, it influences fruit thinning and reduces the differentiation of flower buds. It has been shown, in many fruits, that gibberellins influence fruit development, especially at the younger stage of fruit (Kondo & Mizuno, 1989).

There are some variable responses to GA_3. Sweet cherry fruits treated with GA_3 were significantly firmer than fruits not treated; there were no differences between single and multiple GA_3 treatments (Kappel & MacDonald, 2002). The use of GA_3 increased fruit firmness at harvest, decreased the rate of fruit softening and delayed fruit maturity for the late-maturing genotypes, but had no significant effect on early-maturing fruits (Choi, Wiersma, Toivonen, & Kappel, 2002). GA_3 increased fruit firmness, soluble solids and fruit weight (Basak,

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Rozpara, & Grzyb, 1998) and delayed time of ripening (Andrews & Shulin, 1995; Demirsoy & Bilgener, 2000; Facteau, Rowe, & Chesnut, 1985). Gibberellic treatment decreased cracking indices, but there were no significant effects on fruit firmness, TSS content or fruit weight (Demirsoy & Bilgener, 1998). GA_3 decreased the activities of polygalacturonase (PG) and pectinmethylesterase (PME) (Andrews & Shulin, 1995). These cell wall hydrolytic enzymes affect softening in cherry fruit and GA_3 may maintain fruit firmness by regulating their activities (Kondo & Danjo, 2001). The more significant effect of GA_3 treatment may be to suppress or delay the development of the pitting symptom on bruised fruit. GA_3 treatment appears to reduce the incidence of sweet cherry disorders by more than one mechanism (Looney & Lidster, 1980) and also seems to reduce sensitivity of fruits to bruises (Basak et al., 1998). Fruits treated with GA_3 maintain their higher firmness during storage (Clayton, Biasi, Agar, Southwick, & Mitcham, 2003).

Use of GA_3 in the fresh sweet cherries market in western North America, where dry local weather (125–250 mm/year) occurs, has become a standard practice (Kappel & MacDonald, 2002) but, in humid weather conditions (up to 1000 mm/year), the use of gibberellic acid has not yet been tested. Some of the variable response to GA_3 is probably related to extremely important factors: temperature, precipitation, nutrition, water status, light, humidity, leaf/fruit ratio (Facteau et al., 1985). The extent to which environmental conditions, management practices or other factors cause yearly differences of fruit quality remains uncertain (Clayton et al., 2003).

The aim of this research is to establish the influence of gibberellic acid on the physical and chemical properties (development of fruit colour, firmness of fruits, cracking index, water uptake, soluble solids content, total acidity, fruit dimensions) of fruits of three sweet cherry cultivars, 'Van', 'Sunburst' and 'Elisa', grown in a climate with frequent rainfall during fruit maturation. The objective of this work is also to investigate the possibility of reducing the fruit cracking by the use of gibberellic acid.

2. Materials and methods

2.1. Plant material

The experiment work was carried out in 2002 on 7-year- old mature 'Van' (+18), 'Sunburst' (+20) and 'Elisa' (+23) sweet cherry trees (*Prunus avium* L.), grafted onto Mazzard rootstock, in the Fruit Growing Centre, Bilje, near Nova Gorica (Slovenia). Among similar sized and oriented branches on the cherry trees, six branches were randomly selected for each cultivar. 20 cherries were sampled randomly and marked on each branch for the fruit colour measurements. Three of the six branches were sprayed with GA_3 and the other three branches were sprayed with water and were protected from spraying with GA_3. GA_3 was sprayed at a concentration of 20 ppm, at transition from green to straw-yellow colour of fruits (about 7 weeks after full bloom, on 16th of May). It is generally thought that the start of Stage II of fruit development (the lag-phase, at 'pit-hardening') coincides with the straw colour stage (Kappel & MacDonald, 2002) or the start of the final fruit swell. Cherry fruits were picked at commercial maturity on the basis of subjective estimation of fruit colour. The fruit colour is the most reliable indicator of sweet cherry fruit maturity (Proebsting & Mills, 1981; Drake & Fellman, 1987), therefore the visual estimation of the cherry colour was essential in defining the time of harvest.

2.2. Measurements and analyses

For each marked cherry, three variables of skin colour, brightness (L), intensity of red–green (a) and yellow–blue colour (b), were measured with a Minolta CR 300 Chromameter over 6 time points at three or four day intervals during maturation (date 1: 20th of May, date 2: 23th of May, date 3: 27th of May, date 4: 30th of May, date 5: 3rd of June and date 6: 6th of June) in 2002 to detect differences in ripening. Fruit colour was measured on the opposite site of the fruit suture. Untreated cherries of cvs. 'Van' and 'Sunburst' were picked on 3rd of June and fruits treated with GA_3 on 6th of June. So, five time points of fruit colour were measured for control cherries and six time points for treated fruits of cvs. 'Van' and 'Sunburst'. The fruit colour of cv. 'Elisa' was determined in six time points for control and treated fruits. After 6th of June, the fruits of cv. 'Elisa' experienced certain cracking and were picked all at the same time (10th of June). Because of cracking there were no measurements of fruit colour at the picking date on cherries of cv. 'Elisa', on even other measurements after picking.

The other observed parameters (cracking index, water uptake, firmness, fruit dimensions: height, width, thickness, weight, soluble solids (SS) content and acidity) were measured at fruit maturity when all cherries from the chosen branches were picked and subsamples of cherries for different measurements were sampled for cvs. 'Van' and 'Sunburst'. 20 marked fruits for colour measurements were used for measurements of cracking index, water uptake, fruit dimensions (height, width, thickness and fruit weight). Among all picked intact cherries from each branch, except those fruits, marked for fruit colour measurements, 20 intact fruits were chosen for measurements of firmness (on three sides of each fruit; 2 mm needle, Chatillon penetrometer), SS content and acidity. Soluble solids concentration was measured on each of 20 fruits using a digital refrac-

tometer ATAGO WM-7. Acidity (TA) was measured using a Titrino autotitrator on the sample prepared from the 20 fruits. In addition, 30 fruits for measurements of fruit weight were chosen among all picked fruits.

The water uptake and susceptibility to fruit cracking were determined by immersion of fruits in distilled water at 24 ± 1 °C for 6 h. Twenty fruits were chosen and the fruit stalks were excised near the base to prevent fruit puncture. Every 2 h, fruits were taken out of water and were gently blotted dry. After weighing, they were placed back into water. This was repeated three times. The results were presented as cumulative water uptake, expressed as mg water/g fresh weight. The numbers of cracked fruits were counted every 2 h and the cracking index was calculated according to the method of Demirsoy and Bilgener (1998).

2.3. Statistics

For analysing fruit colour changes during ripening (variables *L*, *a* and *b*), the experiment was set up as a factorial repeated measures experiment with two fixed (GA_3 treatment and repeated factor time) and one nested random factor (branch). Repeated measures linear mixed models (McCulloch & Searle, 2001) were used for testing data of fruit colour and firmness. Because of evident differences in ripening, the statistical analysis was done for each of three cultivars, separately. For analysing fruit firmness, the experiment was set up as a factorial repeated measures experiment with three fixed (GA_3 treatment, cultivar and repeated factor site) and one nested random factor (branch).

Two-way ANOVA was used to analyse influence of the two cultivars and GA_3 treatment on water uptake. Multivariate analysis of variance (MANOVA) was used for analysis of influence of the two cultivars and GA_3 treatment on fruit dimensions (weight, height, width, thickness) and soluble solids content. Multiple logistic regression was used for analysis of cracking index dependence on cultivar and GA_3 treatment.

3. Results and discussion

3.1. Weather

Fig. 1 presents weather conditions during the experiment (16th of May to 10th of June 2002). The amount of precipitation in the last 16 days of May 2002 was 65.5 mm and exceeded the 10-year-period monthly mean (52.7 mm). The average number of rainy days in May over the period of 10 years is 3.2, but in May 2002 there were seven rainy days during our experiment. The amount of precipitation in the first 10 days of June 2002 was also high, particularly on 7th of June, with 47 mm.

3.2. Colour measurements

Fruit ripening is a coordinated series of biochemical processes that result in the synthesis and degradation of pigments (Dolenc-Šturm, Štampar, & Usenik, 1999; Speirs & Brady, 1991; Šturm, Koron, & Štampar, 2003). Fruit colour measurement may show how GA_3 influences the development of fruit colour. Does it influence colour in the same way for different cultivars? Does the colour change with time in the same way if the fruits are treated with GA_3 or if they are not?

After the first exploratory data analysis of colour variables, we had to eliminate the data for some cherries from the further analysis. Thus, the number of 20 cherries per branch was reduced to 10–19 cherries per

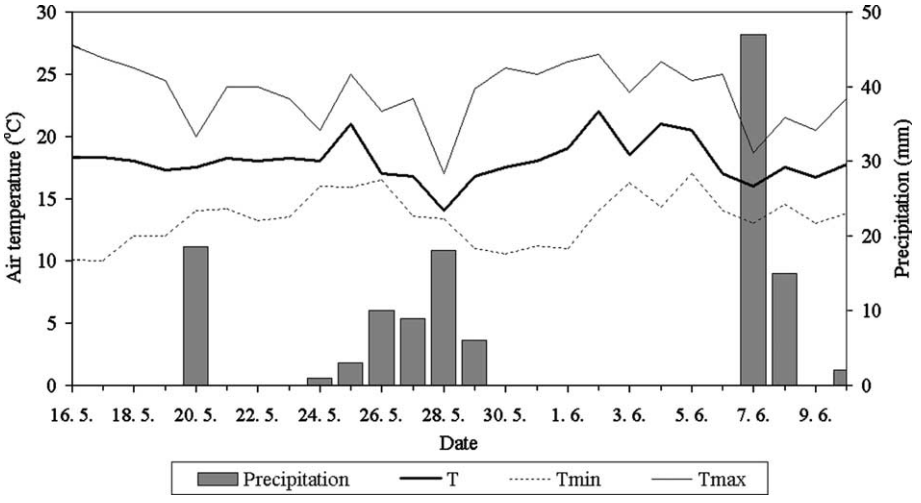

Fig. 1. The daily mean (*T*), minimum (T_{min}) and maximum (T_{max}) air temperature and daily precipitation in Bilje in the period 16th May to 10th June 2002.

branch. Because of the hierarchical structure of the experiment, the error variability of colour variables can be divided into two parts: variability among branches and variability among cherries on the same branch (Table 1). There was much greater variability among cherries inside branches than among branches for all three variables, L, a and b, and changes with fruit ripening. The pattern of variability of a and b is very similar to that of L.

The means of colour variables and standard errors are presented in Tables 2–4. The more mature the fruits, the lower were the values L and b, and the higher was the value a (Figs. 2–4). This means that the fruits became darker, redder and less yellowish. For all three variables and cultivars, variability changes with time. The mean values of L are higher if the cherries are treated with GA_3 than if they are not, but the differences between means are significant only for the dates 3 and 4 for cv.'Van' (Table 2), for the dates 4 and 5 for cv. 'Sunburst' (Table 3) and for the dates 4, 5 and 6 for cv. 'Elisa' (Table 4). In the case of the variable a, the GA_3 treatment in general gives lower values, but differences are significant only for the dates 3 and 4 for cv. 'Van', for the date 4 for cv. 'Sunburst' and for the dates 4, 5 and 6 for cv. 'Elisa'. Most differences are significant for the variable b, almost all the period for cv. 'Van', the last two dates for cv. 'Sunburst' and for the dates 4, 5 and 6 for cv. 'Elisa'.

Table 1
The structure of variance component of error variance of L (brightness) due to differences between branches and between cherries inside branches for each date and each cultivar separately

Date	'Van'		'Sunburst'		'Elisa'	
	Between branches	Between cherries	Between branches	Between cherries	Between branches	Between cherries
1	13	87	38	62	16	84
2	35	65	49	51	10	90
3	32	68	34	66	19	81
4	29	71	32	68	30	70
5	39	61	32	68	28	72
6	29	71	24	76	14	86

Table 2
Means of colour variables (L, a and b) with standard errors for cv. 'Van' and significance level for testing the contrast such that there is no difference between means of GA_3 and control

Date	'Van'											
	L				a				b			
	Mean		SE		Mean		SE		Mean		SE	
	Control	GA_3		p	Control	GA_3		p	Control	GA_3		p
1	75.1	75.0	1.2		−7.2	−9.4	2.6		41.3	43.2	1.4	
2	73.0	75.5	2.5		4.0	−3.8	5.4		37.5	42.2	2.2	0.010
3	63.0	71.2	4.3	0.002	24.0	8.6	7.5	0.001	30.6	37.9	2.6	0.000
4	51.9	60.3	4.6	0.001	37.4	28.0	5.3	0.013	25.6	31.4	2.1	0.003
5	37.5	41.1	2.2		34.8	38.8	2.7		15.8	20.0	2.6	0.018
6		35.9				31.1				12.9		

Table 3
Mean values of colour variables (L, a and b) with standard errors for cv. 'Sunburst' and significance level for testing the contrast such that there is no difference between means of GA_3 and control

Date	'Sunburst'											
	L				a				b			
	Mean		SE		Mean		SE		Mean		SE	
	Control	GA_3		p	Control	GA_3		p	Control	GA_3		p
1	72.3	72.9	1.6		−15.7	−15.3	1.2		44.7	44.0	1.2	
2	76.1	76.2	1.4		−11.0	−11.8	1.8		44.4	44.1	1.8	
3	75.7	77.3	2.2		0.2	−5.1	5.2		39.0	42.1	5.2	
4	65.0	72.1	3.7	0.000	23.7	11.1	6.9	0.001	29.8	35.5	6.9	0.001
5	45.3	50.8	3.8	0.004	40.5	38.7	3.3		21.2	24.8	3.3	0.023
6		45.3				39.6				21.4		

Table 4
Mean values of colour variables (L, a and b) with standard errors for cv. 'Elisa' and significance level for testing the contrast such that there is no difference between means of GA_3 and control

Date	'Elisa'											
	L				a				b			
	Mean		SE		Mean		SE		Mean		SE	
	Control	GA_3		p	Control	GA_3		p	Control	GA_3		p
1	72.4	73.5	1.2		−13.5	−12.8	1.2		40.6	40.1	0.8	
2	74.5	75.5	1.1		−8.8	−9.5	1.8		39.4	39.2	1.2	
3	76.1	76.8	1.6		−3.8	−6.3	2.8		36.7	37.1	1.4	
4	72.0	77.4	2.7	0.003	8.1	−3.4	5.5	0.000	32.1	35.7	2.1	0.000
5	57.0	68.4	5.3	0.000	32.0	17.2	7.9	0.000	23.9	27.8	1.9	0.000
6	46.0	58.5	4.7	0.000	39.7	30.8	6.3	0.000	20.1	22.5	1.7	0.003

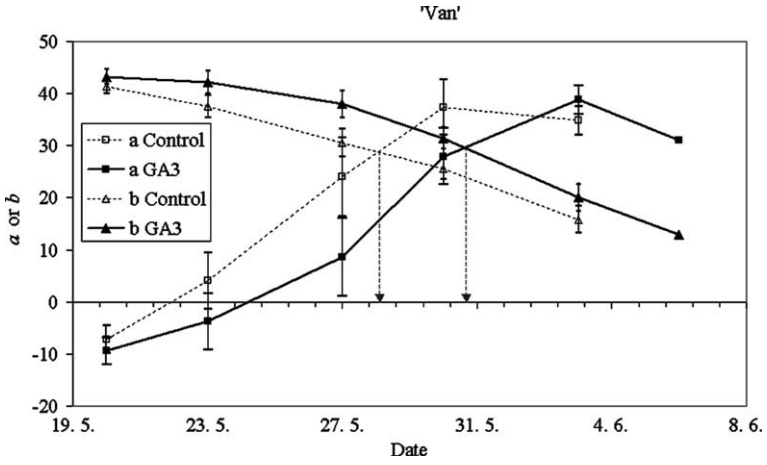

Fig. 2. The development of fruit colour (variables a and b) during fruit ripening of cv. 'Van' after GA_3 treatment.

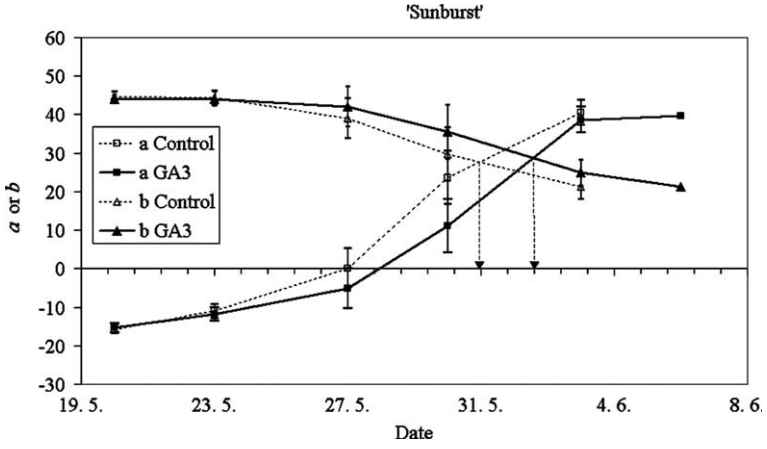

Fig. 3. The development of fruit colour (variables a and b) during fruit ripening of cv. 'Sunburst' after GA_3 treatment.

On average, spraying with GA_3 caused the fruits to mature later (Figs. 2–4). The estimated technological maturity (this is when variable a equals variable b) appeared in GA_3-treated fruits on average, a few days later than in the control (Figs. 2–4). This is for cv. 'Van' between dates 3 and 4 (control) and between dates 4 and 5 (GA_3). If we assume that cherry colour changes linearly with time between these dates, we can see that the difference is about 3 days. For cv. 'Sunburst' the results indicate that there is about a 2 day difference between treatments. For cv. 'Elisa' the technological maturity can be estimated between

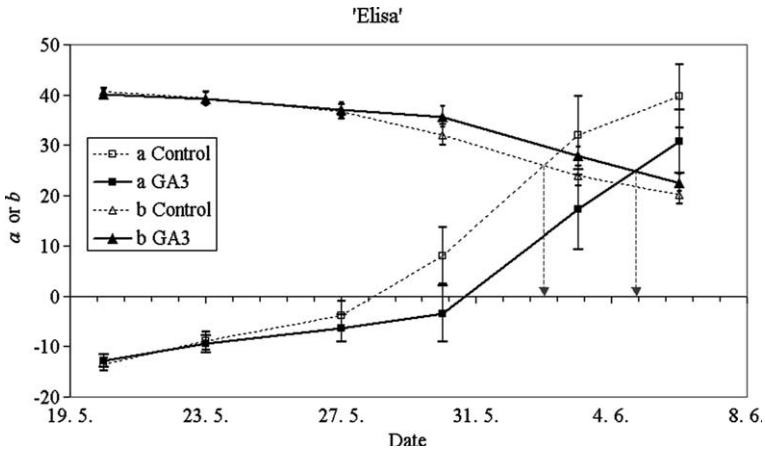

Fig. 4. The development of fruit colour (variables *a* and *b*) during fruit ripening of cv. 'Elisa' after GA_3 treatment.

dates 4 and 5 (control) and between dates 5 and 6 (GA_3).

The difference between treatments can also be observed in transition from negative values to positive values of variable *a*, which presents the beginning of fruit pigmentation (Figs. 2–4). In the experiments the fruits treated with GA_3 underwent this transition few days later than the fruits of the control: by cv. 'Van' between dates 1 and 2 (control) and between dates 2 and 3 (GA_3), by cv. 'Sunburst' at date 3 (control) and between dates 3 and 4 (GA_3) and by cv. 'Elisa' between dates 3 and 4 (control) and between dates 4 and 5 (GA_3).

Every cultivar develops its own process of maturing. As Figs. 2–4 display the order of the cultivars with regard to the maturity was as follows: the fastest maturing cultivar was 'Van', followed by the cv. 'Sunburst' and cv. 'Elisa'. Cv. 'Elisa', as the latest cultivar, represented very slow alterations of variables *a*, *b* and *L* after treatment with GA_3. The differences between the earliest and the latest cultivar can be explained by different times of maturity and different lengths of lag-phase (Kappel & MacDonald, 2002).

Our results show that the treatment with GA_3 causes a slower ripening of cherries and has similar effects on the maturing of all the cultivars (Andrews & Shulin, 1995; Demirsoy & Bilgener, 2000; Kondo & Danjo, 2001; Facteau et al., 1985; Looney & Lidster, 1980). Delayed fruit maturity is not seen as a desirable effect by producers in areas where earliness in the market is a major asset but growers in the areas with late maturing cultivars can extend the harvest period (Looney, 1996).

3.3. Firmness of fruits

Firmness was measured only for cvs. 'Van' and 'Sunburst' on three sides of the fruit. The means of firmness were systematically higher for the cherries treated with GA_3 than for untreated fruits of cvs. 'Van' and 'Sunburst' (Fig. 5), which is in agreement with several authors (Basak et al., 1998; Kappel & MacDonald, 2002), but the variability of data is too high to allow them to be significant at $\alpha = 0.05$ (Table 5). Spraying with GA_3 significantly increased the firmness of the 'Van' fruits at $\alpha = 0.10$. Variability of data of fruit firmness can be ascribed to precipitation during ripeness and thus

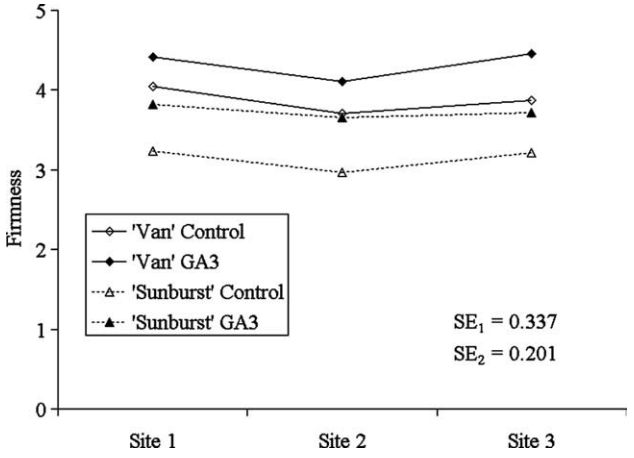

Fig. 5. The means of firmness for all treatment combinations with SE_1 for the comparison of means between treatments at the same level of repeated factor site and SE_2 for the comparison of means between different levels of site at the same level of other factors.

Table 5
The results of *F* test for firmness of cvs. 'Van' and' Sunburst' fruits

Source	Firmness	
	F	*p*
GA_3	3.8	0.087
Cultivar	6.2	0.037*
Side	21.2	0.000*
Cultivar * GA_3	0.07	0.797
Cultivar * side	1.1	0.336
GA_3 * side	0.4	0.649
GA_3 * side * cultivar	2.7	0.068

Significance at $\alpha = 0.05$.

differences in fruit softening. Variability of firmness was higher in GA_3-treated, fruits where ripeness process was slower. Within a genotype, it has also been found that fruit firmness is dependent on climatic conditions (Christensen, 1995), crop load and rootstock. Rainfall during the maturation process causes fruit softening. Softening of fruits is a consequence of biochemical processes in the plant cell which then influence the chemical components and the structure of the cell wall.

In sweet cherry fruit, firmness is one of the most important attributes and it is often used for fruit quality assessment (Esti et al., 2002). Our results show that fruits of 'Van' were firmer than 'Sunburst' fruits. Late cultivars were found to be firm and early cultivar were generally much softer (Christensen, 1995). Cvs. 'Van' and 'Sunburst' ripen very closely, so the differences in firmness are dependent on the genotype. There are considerable genotypic differences in fruit firmness in sweet cherry (Christensen, 1995; Esti et al., 2002). Cv. 'Van' is described as a cultivar with firm flesh and cv. 'Sunburst' with semifirm to firm flesh. Firmness character of cvs. 'Van' and 'Sunburst' did not change, in spite of precipitation during ripeness.

3.4. Fruit cracking

Treatment with GA_3 resulted in lower cracking index in 'Van' and 'Sunburst' (Fig. 6). After 2 h, one fruit of cv. 'Van' treated with GA_3 cracked and the same happened to four fruits of cv. 'Sunburst' (3 untreated fruits and one GA_3-treated fruit). We established that, after 4 h in water, the cracking index was smaller for the cherries treated with GA_3 (4% in 'Van' and 20% in 'Sunburst') but the difference was significant only for the 'Sunburst'. Untreated fruits were 6.6-fold more prone to cracking than GA_3-treated fruits (odds ratio 6.6 at $p = 0.003$). The cv. 'Sunburst' fruits were 2.6-fold more liable to cracking than the fruits of cv. 'Van' (odds ratio 2.6 at $p = 0.063$). The interaction between the cultivar and spraying was not statistically significant.

After 6 h, the cracking index of treated cherries stayed smaller than that of untreated cherries (10% for 'Van' and 12% for 'Sunburst') but the differences were not significant. The tendency of untreated fruits to crack is 1.7-fold higher than the tendency of GA_3-treated fruits, but the relationship is statistically significant at $p = 0.064$ (odds ratio 1.7).

Considerable differences between cultivars were observed. 'Van' fruits cracked in large numbers after 6 h in the water (even higher than fruits of 'Sunburst'), but untreated fruits of 'Sunburst' cracked even after 4 h. That means that, after thunder showers on hot days, untreated fruits of 'Sunburst' will crack to a larger extent than 'Van' fruits and 'Van' fruits will crack more in the long wet period. Fruit cracking is one of the major problems in sweet cherry production. In some years with high precipitation and with sensitive cultivars, fruit cracking can be up to 90%. Most cultivars show an increasing susceptibility to cracking with increasing maturity (Christensen, 1996). Christensen (1996) found out that cv. 'Van' shows cracking as early as the beginning of the third growth phase but this character is influenced by climatic conditions. Application of GA_3 had a variable influence on the number of cracked fruits (Basak et al., 1998; Demirsoy & Bilgener, 1998; Looney, 1996).

3.5. Water uptake

Fruit cracking is thought to be due to increased turgor caused by water uptake through the fruit skin. The GA_3-treated fruits absorbed, in 6 h, rather more water than the untreated fruits, but differences are not significant. Treated fruits of cv. 'Van' absorbed, on average, 20.7 mg of water/g fresh weight and untreated fruits 15.7 mg/g fresh weight. The water uptake of treated fruits of cv. 'Sunburst' was 9.9 and untreated fruits 8.5 mg/g (SE = 3.67 mg/g). Demirsoy and Bilgener (1998) found that water uptake was not affected by GA_3.

In our experiment, water uptake, after 6 h of immersion of cv. 'Van' fruits, was higher than water uptake of fruits of cv. 'Sunburst' (Fig. 7). Differences

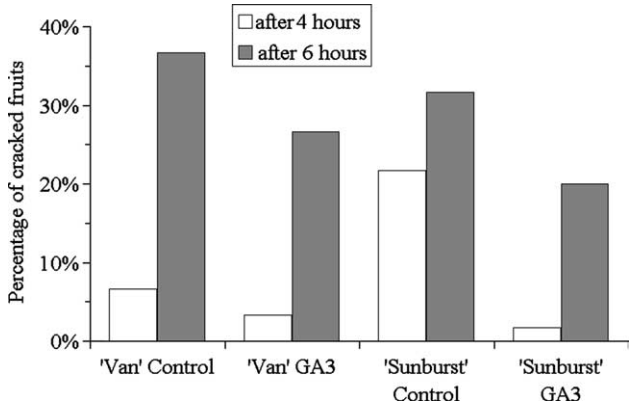

Fig. 6. The percentage of cracked fruits for all treatment combinations after 4 and 6 h standing in water.

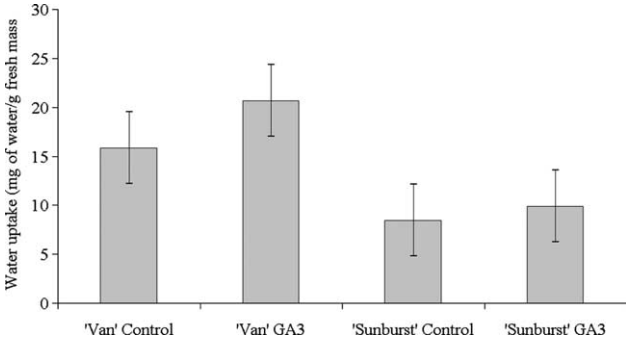

Fig. 7. The means of water uptake with standard errors for all treatment combinations.

Table 6
The mean fruit dimensions, SS and acidity contents

	Height (cm)	Width (cm)	Thickness (cm)	Weight (g)	SS (%)	Acidity
'Van' control	20.52a	24.93a	21.14a	7.15a	13.84a	10.53
'Van' GA_3	21.95b	22.00b	26.06b	7.90a	14.56a	10.01
'Sunburst' control	23.38c	25.64c	22.35a	8.67a	13.54a	8.27
'Sunburst' GA_3	24.53d	24.39d	25.62b	9.63a	13.91a	7.83
SE	0.47	0.56	0.90	0.45a	0.45	–

(a–d) means followed by the same letter were not significantly different at $\alpha = 0.05$.

between cultivars in water uptake were significant. Fruit cracking of treated and untreated 'Van' fruits after 6 h immersion in water, was higher than cracking of 'Sunburst' treated and untreated fruits. Fruits of cvs. 'Van' and 'Sunburst' treated with GA_3 had higher turgor and lower cracking index than the control. Water uptake of GA_3-treated fruits is therefore inversely proportional to cracking index.

Gibberellic acid-treated fruits had rather more water uptake and lower cracking index, which shows the higher epidermis elasticity of treated fruits. Our results show that after 4 h, there was low fruit cracking (except untreated fruits of cv. 'Sunburst'), fruit cracking was increased after 6 h in both cultivars and of both treated and untreated fruits. By increasing cell elasticity, GA_3 could reduce the fruit cracking when the fruit wetting was less than 4 h (Larsen, Fritts, Patten, & Patterson, 1983). Demirsoy and Bilgener (2000) suggested that GA_3 influences cuticula thickness, and dimensions of the epidermal cells but this effect differed according to the cultivars.

3.6. Fruit dimensions and SS content

Fruit weight is the most important of the fruit dimensions, on which is dependent fruit value (price). Gibberellic-treated fruits were larger than untreated fruits (in fruit weight), but the differences were significant only by $\alpha = 0.10$ (Table 6). Treated fruits of 'Van' had on average, a higher fruit weight (by 0.75 g) than untreated fruits and of 'Sunburst' by 1 g. The most important benefits of GA_3 are a reliable increase of fruit size of about 10% (Looney, 1996). Increased firmness is a more consistent response to GA_3 and there are not always changes in fruit weight and SS (Facteau et al., 1985).

There were also significant differences in fruit dimensions between cultivars. Fruit dimensions (height, width and thickness) of both cultivars were significantly affected by treatment with GA_3. The fruits treated with GA_3, were higher, thicker and lower in width. Treated fruits had, on average, more soluble solids than untreated fruits (0.7 °Brix more SS in 'Van' and 0.33 °Brix in 'Sunburst') but differences were not significant (Looney & Lidster, 1980). Acidities of both cultivars are lower after GA_3 treatment than in the control.

4. Conclusion

The application of gibberellic acid in the sweet cherry causes slower fruit ripening. The GA_3 spraying expenses are met by a higher yield and better quality. The process of maturity is delayed, the yield is higher (fruit cracking is reduced) and the fruit quality is better (the fruit weight and SS content increase). The response of sweet cherry fruits to GA_3 spraying is dependent on the properties of the cultivar. In the case of high precipitation during maturing of fruits, the GA_3 spraying decreases the cracking but does not eliminate it. It is wise to plant cultivars which are less susceptible to cracking and further reduce the cracking by the use of gibberellic acid in the areas where earliness at the market is not a major demand.

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